IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	:	10/028,730	Confirmation No. 4112
Applicant	:	Michael Collins	
Filed	:	10/19/2001	
TC/A.U.	:	3746	
Examiner	:	Han L Liu	
Docket No.	:	00-682	
Customer No.	:	34704	

#7

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

DECLARATION OF MICHAEL COLLINS,
RICHARD D'AVERSA AND MICHAEL J. O'BRIEN

1. We, the below signed, are co-inventors of the invention as set forth and claimed in the above-identified pending application. We understand that this application is being rejected based upon another application which was filed on April 21, 2000.
2. Attached hereto is a copy of the invention disclosure for this invention which is dated prior to the aforesaid April 21, 2000 date. As evidenced by this document, we conceived the present invention, as set forth in the claims of the present application, prior to the filing date of the other application.
3. From prior to the filing date of the other application through to constructive reduction to practice of the present application, we exercised diligence in accomplishing the constructive reduction to practice.
4. The invention was constructively reduced to practice through filing of this application on October 19, 2001. From prior to the filing date of the other application through to the filing date of this application, we communicated with in house and outside counsel who prepared this case, reviewed drafts of the application including providing comments on same, and executed documents leading to the filing of the application on the aforesaid date.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

_____
Michael Collins

_____
Date

_____
Richard D'Aversa

_____
Date

_____
Michael J. O'Brien

_____
Date

IDEA RECORD

Carrier
A United Technologies Company

Patent Dept. Docket No. 9698

1. TITLE OF INVENTION
Compressor Monitor - Recip Compressor Protection Module with Communications

2. INVENTOR(S) ~~FULL NAME~~(S) (printed or typed)
Richard Denis D'Amsa - Michael Collins
(First) (Middle) (Last) Division and Location Citizenship

– CCCD – Syracuse, NY – U.S.A.

Post-It™ brand fax transmittal memo 7671	# of pages ▸ 28
To Bryan Rockwell	From Bill Bush
Co.	Co.
Dept.	Phone #
Fax #	Fax #

3. This idea was first conceived on or about the 305 day of 1998 under the following circumstances:
This was something I saw a need for early in my Carrier Career when I was with [illegible] engineering, but electronics and costs would not make this economically available at the time.

4. If work has been done on the idea, briefly describe when and in what manner the earliest work was begun and the idea first tested.
We developed a program to build this device with Carrier Electronics

5. If the idea was conceived under or relates to any government or private contract, state the name of the contract.
—

6. APPLICATION AND USE OF IDEA

Product model(s), process or project to which Idea relates.

All 06D + E Compressors
All Competitive Recip Compressors

Date of first commercial use (if any) —

Date commercial use is planned (if known) —

7. General object of the invention including the problem to be solved or improvement sought.

This device will monitor key operations of the Compressor & check & makes sure it is operating within its envelope. If it detects a problem it will if connected to an accessary Communications module CALL for Service - Refrigerant Selector - Protector Device.

8. Identify and briefly describe the pertinence of the closet prior art to the idea of which you are aware (e.g. prior products, patents, or publications).

NOTE: Failure to fully state all of the closet prior art known to you may constitute fraud which could jeopardize the validity of a patent on your idea.

The closest product we know that does some of the above is the 7H mm. Screw models, But it does not do all this module will DO.

9. Drawing or diagram of the idea:

See Attached Design Specifications

10. Description of the idea (attach any additional information which may be helpful in understanding and evaluating it).

See Attached Design Specifications

11. Names of persons within Carrier to whom this idea has been disclosed.

Paul Tollar, Terry Nores, M. Obrien
A. Price, R. Kobar, OEM sales group
+ Carrier Electronics Design team

12. Name, date, and affiliation of any persons outside Carrier to whom the idea has been disclosed.

—

13. Explain the idea to two persons who understand it, have them read this disclosure and sign and date the statement below:

WE HAVE READ AND UNDERSTOOD THIS DISCLOSURE.

NAME: Jeff Thom DATE: 11/9/99

NAME: Paul Tollar DATE: 11/9/99

14. Each inventor sign and date this form and send the hand signed copy to the Patent Department.

Name	Date
Richard D'Amico	11/9/99
Michael Collins	11/9/99

UNITED TECHNOLOGIES CARRIER

CARRIER ELECTRONICS

DESIGN AND RELIABILITY REQUIREMENTS

TITLE: Reciprocating Compressor Protection Module

RCPM

CE-DR-98-3017

REV: A
Date: 8/31/99

UNITED TECHNOLOGIES CARRIER

CARRIER ELECTRONICS

ENGINEERING SPECIFICATION

TITLE: Design and Reliability Requirements
Carlyle Reciprocating Compressor Protection Module

PROJECT LEADER,ELECTRONICS	Michael J. O'Brien	DATE
ENGINEERING MGR., ELECTRONICS	Brett Desmarais	DATE
PRODUCT MGR., CE MARKETING	Allison Price	DATE
PROGRAM MANAGER, CARLYLE	Rich D'Aversa	DATE
APPLICATION MANAGER, CARLYLE	Paul Tollar	DATE
PROJECT ENG., CARLYLE	Michael Collins	DATE
ENGINEERING RECORDS		DATE

UNITED TECHNOLOGIES CARRIER

CARRIER ELECTRONICS

DISTRIBUTION LIST

ORIGINAL SIGNEES WHO DO NOT RECEIVE CHANGE PAGES:

ADDITIONAL DISTRIBUTION:

DCP/SCP/SCPCA DISTRIBUTION (PROPOSAL & IMPACT):

UNITED TECHNOLOGIES CARRIER

CARRIER ELECTRONICS

SPECIFICAITON NO. CE-DR-98-3017

REVISIONS

REV LETTER	DESCRIPTION	DATE
A	Original Signature Draft	

Table of Contents

1. INTRODUCTION

1.1. Purpose

This document will define the design and reliability requirements for the Reciprocating Compressor Module (RCPM). This is a new product which will be used by Carlyle Compressor for 06D and 06E reciprocating compressors.

1.2. Scope

The objective of this effort is to provide a reliable and cost effective control which will provide broadband protection for reciprocating compressors. The module is intended to protect the compressor under most circumstances as well as provide prognostic and diagnostic information. This will minimize down time, reduce warranty costs, and allow for faster diagnonis of failed compressors.

There are 3 generic failure types for reciprocating compressors.

- Manufacturer Defect
- Customer misapplication
- Aging compressor

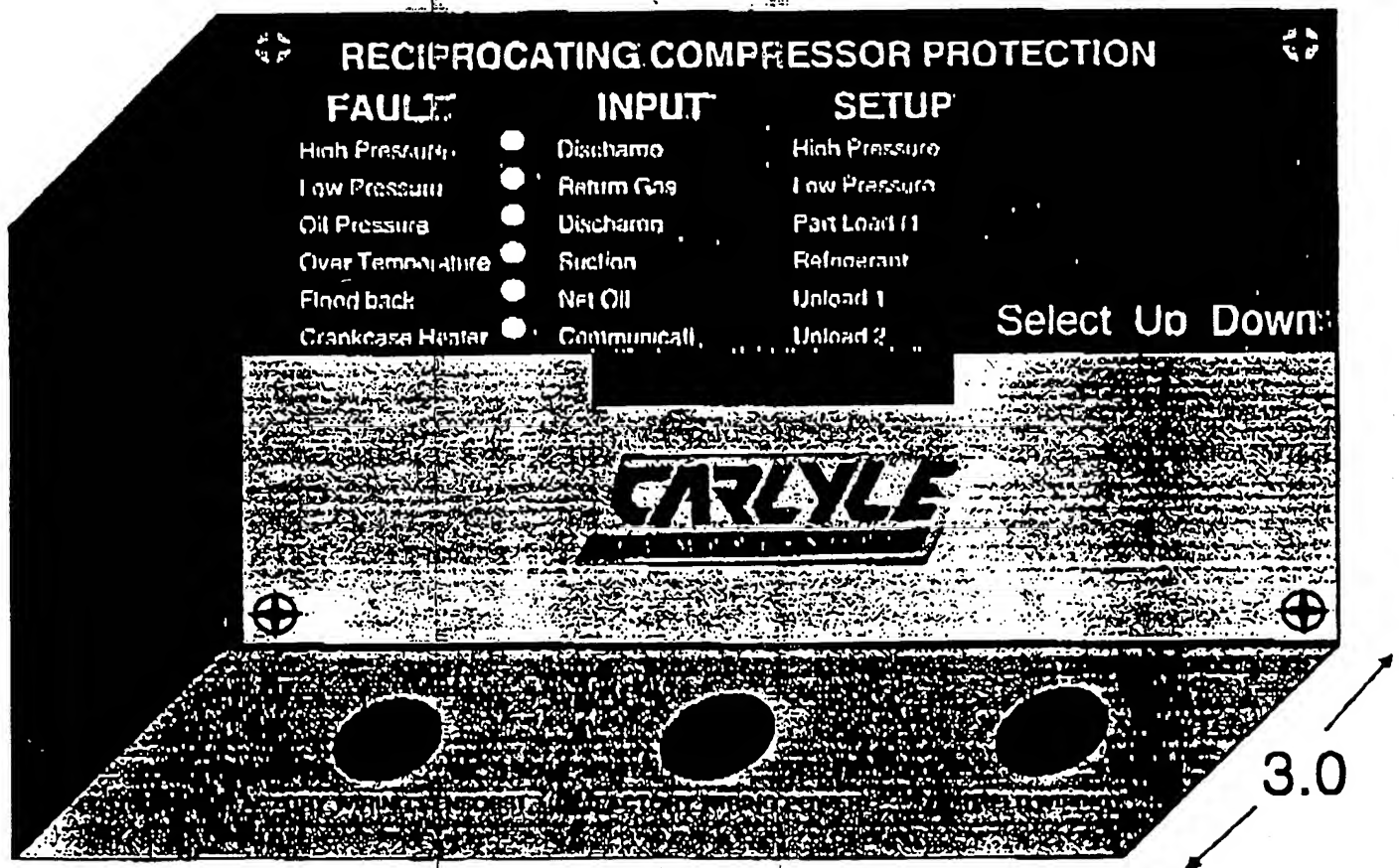
The RCPM will be able to detect improper operating conditions and detect impending failure in most cases. Faults will be managed by immediate shutdown, adjusted operation, or scheduled maintenance. In the case of shutdown, diagnostic information can be retrieved from the RCPM to assist in warranty and reliability evaluation.

The RCPM will be mounted on or near the compressor.

UNITED TECHNOLOGIES CARRIER	SPECIFICATION NO.	REV.	PAGE NO.
	CE-DR-98-3017	A	3 of 20

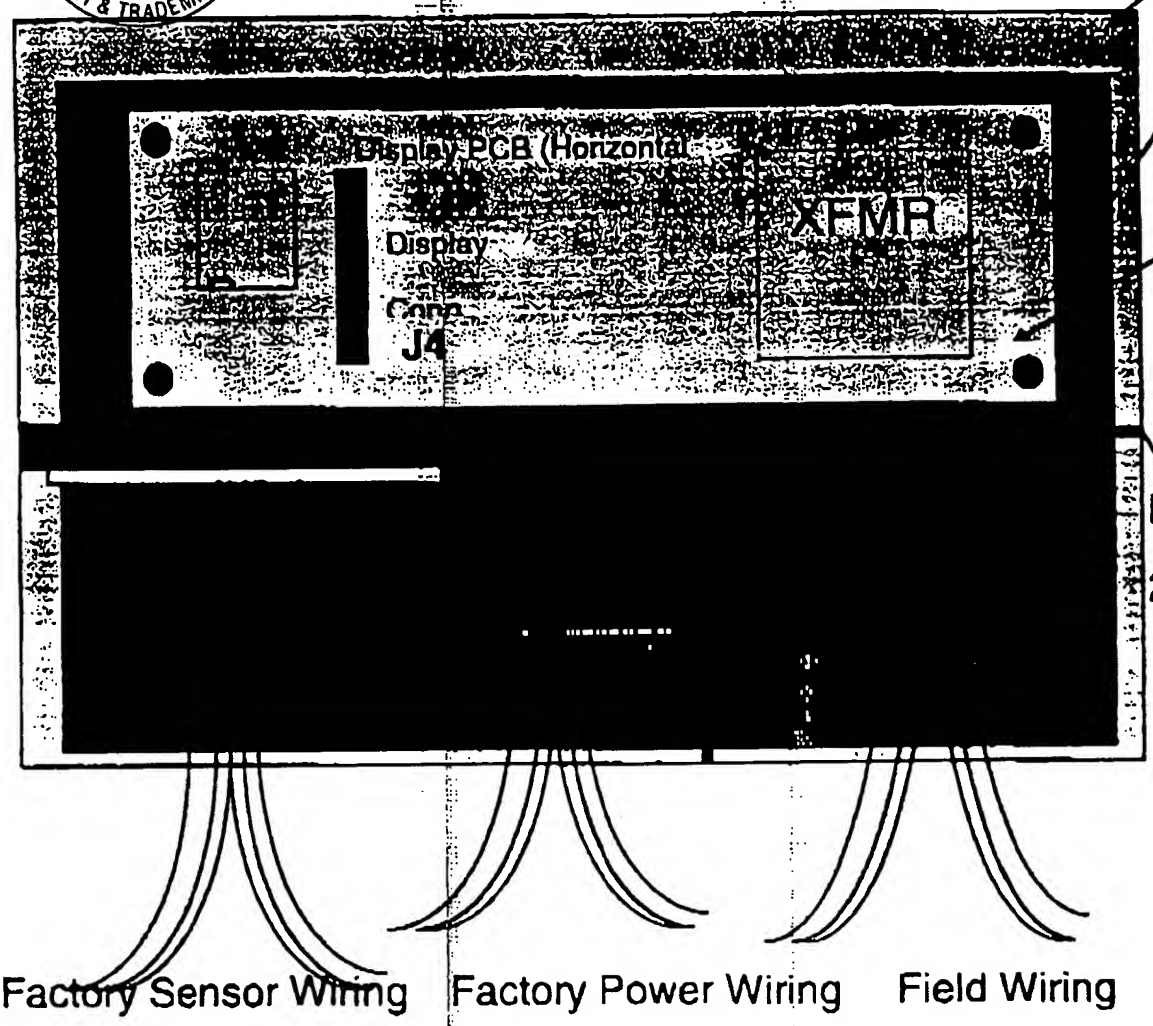
1.3 General Description

The RCPM will consist of a Display and Circuit Board integrated into a painted metal control box which can be mounted on the compressor. The cover will contain the display and will allow the user access to the circuit board. There will be standard sized knockout holes in the side and bottom of the box to allow cable entry.

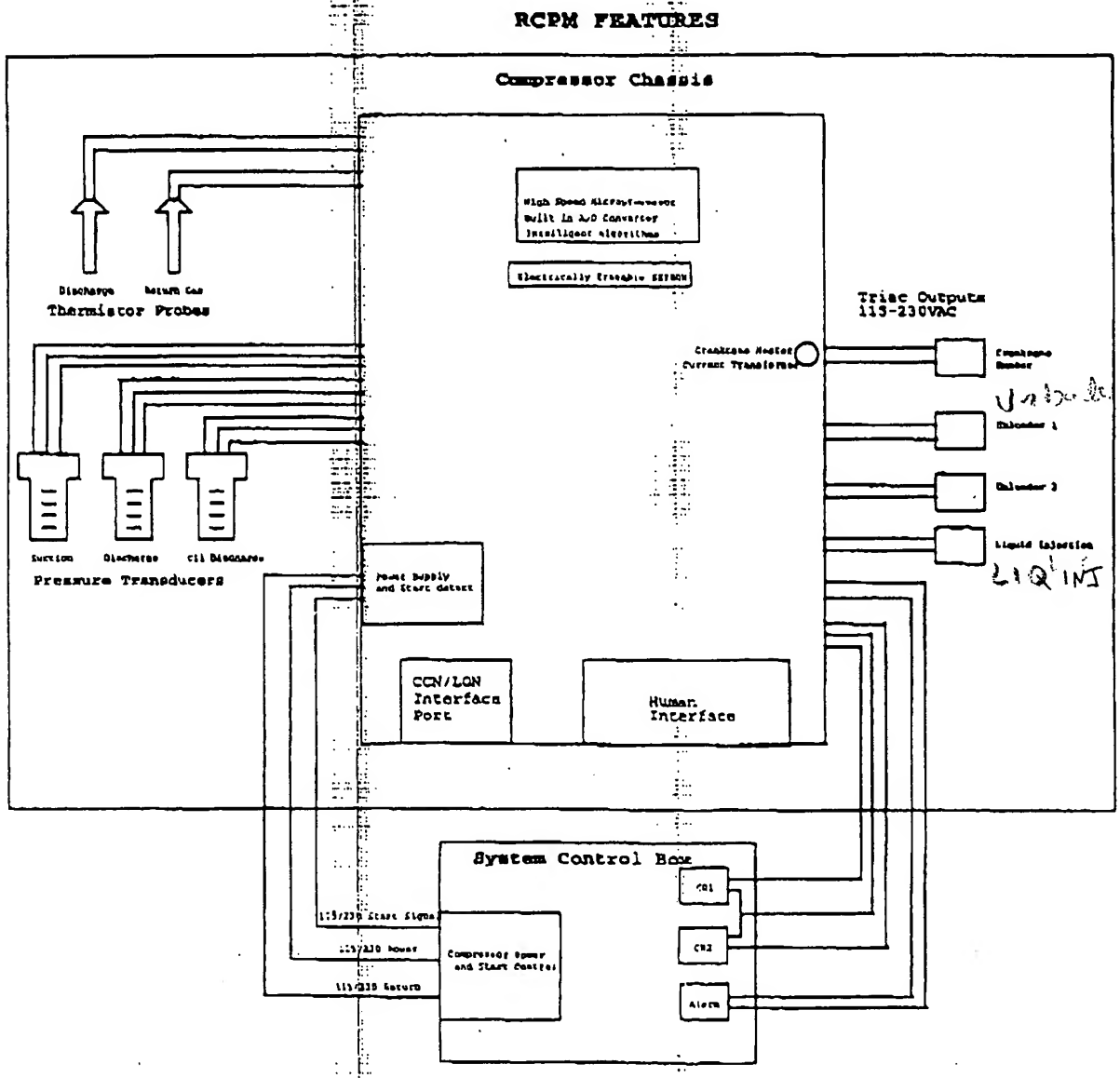


RCPM

RCPM INTERIOR



1.4. Functional Block Diagram



1.5. Features

Protection Algorithms

The primary purpose of the RCPM is compressor protection which has two forms: immediate and prognostic. Immediate protection will sense a failure that is occuring or impending and shut down the compressor immediately. Prognostic protection will sense an impending failure or degradation, adjust the compressor operation accordingly, and warn the user that scheduled maintenance maintenance is required.

The following is a list of compressor failure modes and symptoms that will be addressed by the RCPM.

Details on the algorithms and control actions will be documented in the functional specification.

Failure Mode Or Symptom	Description	Possible Control Action(s)	Sensor(s) Required
High Pressure Protection	This is a safety control (mechanical or electrical) (ARI, ANSI, ASHRAE 15-1978).	Turn off the compressor if the discharge pressure exceeds a threshold value, operator reset is necessary.	Compressor Discharge Pressure
Motor Overheating1 Oil Breakdown Refrigerant Breakdown	Protects motor against overheating effects sensed on the high temperature side which lead to lack of lubrication.	Shuts compressor motor off. Modulate refrigerant injection over motor to cool it.	Compressor Discharge Temperature
Motor Overheating2	Protects against loss of motor lubrication when oil pressure is low.	Shut compressor motor off.	Oil Pressure
Freeze Up	Protects motor against high temperatures due to freeze up effects sensed on the low pressure side.		Compressor Suction Pressure

Failure Mode Or Symptom	Description	Possible Control Action(s)	Sensor(s) Required
Motor Overheating3	Protects against loss of motor lubrication when oil is too cold (viscous).	Turn on oil heater	Compressor Dischare Temperature. Compressor suction temperature.
Refrigerant Loss	Protects against low refrigerant charge and refrigerant loss which could overheat motor.	Shut off compressor.	Return Gas (Suction) Pressure
Slugging	Short term liquid input to the compressor usually happens right after startup due to liquid settling in the evaporator or due to poor EXV control	Turn on warning light or alarm. Record fault in memory. Shut down motor if excessive.	Suction Pressure Return Gas Temperature Discharge Temperature
Floodback	Continuous liquid in the suction gas due to loss of load, excessive refrigerant charge, improper evaporator liquid entry.	Turn on warning light or alarm. Record fault in memory. Shut down motor if excessive.	Suction Pressure Return Gas Temperature Discharge Temperature
Flooded Start	When a large volume of refrigerant accumulates in the crankcase or oil sump at shutdown it dilutes the oil. This happens because at shutdown the compressor is the coldest (lowest) point in the system.	Turn of crankcase heater. Monitor crankcase heater current and display warining light/alarm when heater fails.	Return Gas Temperature Discharge Temperature
Motor Temperature	Protects motor windings and bearings from high temperature effects.	Shuts motor off when a high temperature threshold is exceeded.	Compressor Discharge Temperature
Crankcase Heater Failure	The crankcase heater is energized whenever compressor is off	Warning light is displayed or alarm activated.	Crankcase heater current sensor.

Table 1: Summary of Protection Controls

Because failures are not uniquely tied to sensors, in Table 1 they are numbered when the same failure mode can be concluded using different sensors. For example, Table 1 shows that Motor Overheating can be concluded from up to six sensors, Compressor Discharge Temperature, Compressor discharge Temperature, Oil Temperarture, Oil Pressure, Compressor Suction Pressure, Sump (oil) Temperature.

Specific Failures

The above listed failure modes and potential control actions are designed to reduce the failure rate of the following compressor parts:

- Main bearings
- Crankshaft
- Head Gasket
- Discharge Valve
- Suction Valve
- Motor
- Connecting Rods

Detailed algorithms and failure modes will be listed in the functional specification.

Output Control

The RCPM has the following control functions:

Triac Outputs

1) CR1

2) CR2

3) Liquid injection

4) Crankcase heater ON/OFF

5) Alarm

6) Unloader 1

7) Unloader 2

Winding Type

The RCPM must be able to handle a normal or a part load winding.

Diagnostics

The RCPM will contain 8K non-volatile memory which can be accessed via CCN communication in the event of a compressor shutdown or failure. The operational data must be saved to assist in diagnosing the problem. The exact method and timing of data storage will be defined in the functional specification. Fault conditions must be saved in EEPROM for later revrieval.

Display/ Human Interface

The RCPM will be designed to interface with a human interface which would consist of LED digits, LEDs,and buttons. This interface will allow the user to monitor compressor operational status, monitor compressor output status, monitor compressor input values, and to setup configuration values.

The human interface will be directly driven by the RCPM. It will have 3 eight segment LEDs, 3 push buttons, and 18 individual LEDs.

Operating Status:

Status will be indicated by LEDs next to a list of faults. When a fault occurs, the LED next to its name will light up to indicate the fault.

The following categories will be listed as operating status:

- Overcurrent
- Hi Pressure
- Lo Pressure
- Oil Pressure
- Floodback
- Motor Temp
- Crankcase Heater

Setup/Configuration:

Configuration is to be set using LED displays and push button switches. The user will use one button to select the configurable item and the other two buttons to increase or decrease the value. The configurable item will be indicated by an LED next to its name. The 3 digit LED display will indicate the present value of the selected item. A coded sequence of keystrokes could be required to access configuration.

The following items will be configurable:

1) Part Load winding ON or OFF (Default OFF)
2) High Pressure setting (Default lowest setting)
3) Low Pressure setting (Default highest setting)
4) Refrigerant Type Selection (Default R22)
5) Unloader 1 pressure (Defualt OFF)
6) Unloader 2 pressure (Defualt OFF)

Outputs:

Outputs to be monitored are:

1) CR1
2) CR2
3) Liquid Injection
4) Alarm
5) Unloader 1
6) Unloader 2

Inputs:

The following inputs will be monitored:

1) Discharge Temperature
2) Return Gas Temperture
3) Discharge Pressure
4) Suction Pressure
5) Oil Pressure
6) Communication Status

Option CCN/LON Interface

The RCPM will have an optional communication module interface which will allow control via CCN or LON communication. Hardware will be capable of controlling and connecting to an external CCN or LON Module. Software will allow CCN communication at first production. Software to manage LON communication is a future option and not part of this program.

1.6. References

Carrier Procedures

IDS	Integrated Development System

Carrier Reliability Requirements

CC14FF003	Hi-Pot/Leakage Testing Standard Procedure
CC14AC002	Temperature/Humidity/Life Stress Testing Standard Procedure
CC15BF002	Vibration Testing Standard Procedure
CC15FF001	Shock Testing Standard Procedure
CC15DF003	Corrosion test

Agency Requirements

96/336/CEE	CE Electromagnetic Compatibility
73/23/EEC	CE Low Voltage Directive
UL1998	Software for safety device
UL 873	Temperature Indicating and regulating equipment

IEC EMC Requirements

EN50081	European Norm, Immunity
EN50082	European Norm, Emissions
EN 61000-4-2	Electrostatic Discharge Immunity
EN 61000-4-4	Electrical Fast Transient Immunity
EN 61000-4-5	High Energy Transient Immunity
EN 61000-4-11	Voltage dip immunity
ENV 50140	Permanent Magnetic Field
ENV 50141	Radio Frequency Immunity
ENV 50204	Modulating Electromagnetic Field
EN55022B	Electromagnetic Disturbances Emitted
EN60555	Harmonic & voltage fluctuation immunity

Carrier EMC Requirements

CC15GF001	Radio Frequency Compatibility Standard Procedure
CC15GF002	Electrostatic Discharge Testing Standard Procedure
CC15GF003	Electrical Transient Susceptibility Testing Standard Procedure

2. SYSTEM CONTROL FUNCTIONS AND REQUIREMENTS

2.1. General

The RCPM is a printed circuit board module that is easily attached to a control box with sheet metal screws. The unit operates from115,208,or 230VAC. It is a microcontroller based intelligent module with electrically erasable memory for setpoints and diagnostic data. It will monitor thermistors and pressure transducers. It will offer a variety of protective, diagnostic, and prognostic algorithms. There are triac outputs which can be used for ON/OFF control of motors, valves, and alarms. It can be configured using a remote communication interface.

2.2. Hardware

Power supply

The RCPM shall be able to operate at 115VAC or 208VAC or 230VAC with a frequency of 50HZ or 60HZ. The full power supply range will be 100VAC to 265VAC. A fuse or PTC will be required to limit current.

The RCPM will operate on a 3 wire power supply. One wire will be common. One wire will be continuous power. The third wire is energized when the compressor is commanded to start. The RCPM will derive its operating power from Continuous power and common. The RCPM will monitor the start power line and energize the compressor when this line is energized.

Continuous Power

Start Power

Common

Crankcase Oil Heater current input

The Crankcase heater output of the RCPM will be current monitored. A CT will be placed on board to detect current flowing to the Crankcase heater. This isolated input will be monitored by the RCPM. The accuracy of the CT is not important and will simply detect if current is above or below a determined threshold value.

If no crankcase heater is not installed or is powered separately the unit will continue to operate but the heater warning light will always be on.

Thermistor Inputs

The RCPM will have 2 thermistor inputs requiring 2 wires each.

Thermistors will be a standard 5K @ 25°C type.

Required resolution will be 0.5°C

Shielded wiring is NOT required.

Thermistor usage:

- Discharge
- Return Gas

Pressure transducer Inputs

The RCPM will have 3 pressure transducer inputs requiring 3 wires each.

Each pressure transducer will have a power input, signal output, and ground wire.

5V must be supplied to each pressure transducer @ 20mA each.

Required resolution is 0.5 PSIG

Shielded wiring is NOT required.

Pressure Transducer Usage:

- Suction
- Discharge
- Oil Discharge

Discrete outputs

The RCPM shall have 8 discrete outputs. The discrete outputs can be triacs or relays as long as they meet the requirements. CR1 and CR2 will share a common return and connect to the main control box. Alarm will be a two wire connection to the main control box. Liquid injection, heater, unloader 1, and unloader 2 will each consist of a two wire connection to these items on the compressor. Therefore 5 wires will leave the RCPM to the control box and 8 wires will conect to items on the compressor.

Discrete Output Usage:

Usage	Voltage	Current	Inrush	Power Factor	Cycles
1) CR1	115-230	1.2A	20A	0.30	1,000,000
2) CR2	115-230	0.75A	20A	0.30	1,000,000
3) Liquid Injection	115-230	0.22A	0.75A	0.50	1,000,000
4) Crankcase Heater*	115-230	2.0A	2.0A	1.00	1,000,000
5) Unloader 1	115-230	0.22A	0.75A	0.50	1,000,000
6) Unloader 2	115-230	0.22A	0.75A	0.50	1,000,000
7) Alarm	115-230	0.22	0.75A	1.00	100,000

* The crankcase oil heater output will pass through an onboard CT to allow current monitoring.

Indicator Lights

The RCPM will have 1 indicator LED on the PCB.

Power/Activilty Red

This activity light is for use by service personnel only. They don't need to be viewed by customers.

Optional CCN/LON Interface

A 15 pin option interface will be required. An optional CCN or LON communication module could be conected to the RCPM at this port 5V power and ground would be supplied to this option module.

Hardware to support this option will be available at initial production. Software to support CCN will be available at first production. Software to support LON modules will be added at a later date as a separate program.

The optional module should require no special tools to insert other than a screw driver. Option module connector must meet vibration requirements.

Microcontroller

The RCPM will require intelligent control using a microcontroller which must be capable of monitoring all inputs and appropriatley controlling all outputs in the allotted timeframe. The unit must also be able to handle storage to EEPROM and communication interface.

Non-volatile memory

The unit will require electrically erasable PROM. This non-volatile memory is used for saving configuration information and diagnostic information. In the event of a failure, the EEPROM memory can be retrieved and diagnostic data reviewed. Data to be saved will be listed in functional specification.

2.3. Software

The RCPM will be classified as a UL safety device. All code will be compliant with UL1998.

Software will be embedded in the device at manufacture. It should be well organized, modular, and portable.

All compressor protection algorithms will be contained in the software.

The software must be able to fully monitor inputs, determine any of these fault conditions,and shut off outputs within 250mS maximum.

The exact nature of these algorithms and the timing requirements will be defined in the Carrier Electronics Functional Specification CE-FS-98-3026.

3. RELIABILITY REQUIREMENTS

The control will be in compliance with Carrier reliability standards.

The unit shall be designed for a 15 year life operating at 8760 hrs/year.

First year failure rate	0.5% (5000 PPM)
Long term failure rate	0.2% (2000 PPM)
Units functioning after 15 years	94%

The unit shall be tested in accordance with the following list of Carrier Electronics Reliability Procedures:

CC14FF003	Hi-Pot/Leakage Testing Standard Procedure
CC14AC002	Temperature/Humidity/Life Stress Testing Standard Procedure
CC15BF002	Vibration Testing Standard Procedure
CC15FF001	Shock Testing Standard Procedure

Temperature	Operating:	-20 to 70 degrees C
	Storage:	-40 to 85 degrees C
Humidity	Operating:	10 to 95% without condensation
	Storage:	10 to 95% with condensation
Vibration	Operating:	in all planes/directions, 1.5G @ 20 to 300 HZ.
	Machine Environment:	1.5G @ 300HZ extended time. TBD
Shock	Operating:	5G Peak in all planes/directions, 11ms.
	Storage:	100G Peak in all planes/directions, 11ms.

A reliability test plan and report will be required.

All components shall be tested to Carrier reliability requirements.

4. ELECTROMAGNETIC COMPATIBILITY REQUIREMENTS

The RCPM shall be tested to the following Carrier and IEC requirements to insure a globally compliant module.

This module will be tested to the following standards and will be classified as a **Heavy Industrial Device**:

CC15GF001	Radio Frequency Compatibility Standard Procedure
CC15GF002	Electrostatic Discharge Testing Standard Procedure
CC15GF003	Electrical Transient Susceptibility Testing Standard Procedure

Standard	Description	Required Level
EN 61000-4-2	Electrostatic Discharge Immunity	8KV Contact 16KV air
EN 61000-4-4	Electrical Fast Transient Immunity	4KV Power 2KV I/O
EN 61000-4-5	High Energy Transient Immunity	4KV Power 2KV I/O
EN 61000-4-11	Voltage dip immunity	30% 10ms 60% 100ms
ENV 50140	Permanent Magnetic Field	10V/M 80-1000MHZ
ENV 50141	Radio Frequency Immunity	10V EFF 0.15-80MHZ
ENV 50204	Modulating Electromagnetic Field	10V/M 900MHZ
EN55022B	Electromagnetic Disturbances Emitted	Class B at 10M
EN60555	Harmonic & voltage fluctuation emiss	Class B at 10M

UNITED TECHNOLOGIES CARRIER	SPECIFICATION NO.	REV.	PAGE NO.
	CE-DR-98-3017	A	20 of 20

5. PHYSICAL REQUIREMENTS

The RCPM must be made as small as possible and must be mountable to a compressor.

Maximum Length: 6.5 inches
Maximum Width: 4.5 inches
Maximum Height: 3 inches

The box will be metal painted gray. Knockouts to fit standard conduit will be on the bottom.

The cover will be removable with captive screws. A hinged cover is preferred but not required.

Mounting: The RCPM will be mountable to the compressor. The back of the box will hold a standard bracket for mounting.

Connectors: All connectors on the board must be able to wires and will be screw tight type.

Connector Keying: Connectors must be arranged such that high voltage I/O have connectors which CANNOT fit into low voltage I/O. This will minimize damage due to miswiring.

Connector Spacing: Must meet UL and NEC spacing requirements

6. AGENCY AND REGULATORY APPROVALS

The RCPM will be classified as a SAFETY DEVICE and as a REFRIGERATION CONTROLLER.

UL 873 Temperature Regulating Equipment

UL 1998 Software for safety device

(CSA or CUL equivalent approvals will be required)